SOIL CONSERVATION

HENRY A. WALLACE
Secretary of Agriculture

H. H. BENNETT
Chief, Soil Conservation Service

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Dr. H. H. Bennett, at his desk, receives his field administrators. Standing, left to right, are R. E. Uhland, Region 5; T. S. Buie, Region 2; Dr. W. C. Lowdermilk, Associate Chief; N. E. Winters, Region 7; H. H. Finnell, Region 6; H. G. Calkins, Region 8; J. S. Cutler, Region 3; H. E. Reddick, Region 10; W. A. Rockie, Region 11; L. P. Merrill, Region 4; A. L. Patrick, Region 1. H. J. Clemmer, Region 9, not in picture.

REGIONAL CONSERVATORS TAKE THEIR PROBLEMS TO WASHINGTON CONFERENCE

Conservators of the 11 regions met for the second time this year in Washington, September 24–28. With exactly 7 busy months intervening since the earlier and initial, conference, the field executives devoted themselves to perfecting administrative procedures, adjusting perspectives, and planning for the future.

Dr. H. H. Bennett, chief of the Service, sounded the keynote when he urged teamwork within the organization and cooperation with other agencies. He emphasized the duty of thinking in terms of service to the Nation as a whole.

In deference to problems arising from drought and other conditions peculiar to the region, 1 day's sessions were given over entirely to the West and Southwest.

All principal administrative officers of the Service, together with many members of their staffs, participated in the informal discussions around the long council table.

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D. S. Myer, Chief of the Division of Cooperative Relations and Planning, pointed out the necessity of establishing operation areas on the basis of a more definite formula or plan than has been in use for present demonstration areas. He looked ahead to the inclusion of additional watersheds in future operations. The standard State soil conservation districts law, he explained, offers a convenient model for legislation which will enable Federal Government, States, counties, districts, and communities to develop plans and assume certain responsibilities in the cause of soil conservation. It is expected that needed legislation will differ somewhat in the several States where agriculture's problems are dissimilar. Mr. Myer hopes to speed up the working arrangements with the several States, and depends largely upon the State coordinators to accomplish this end. The first step, in his opinion, is a reading and discussion of the proposed act, followed by the taking of an inventory of the situation in each State and by securing definite suggestions and criticism which will help perfect plans.

"I hope the time will never come when we shall draw a distinct line between operations and research", said Dr. A. G. McCall, acting head of the Division of Research. "We expect to get from you men on the actual firing line many suggestions as to studies, and it is my earnest concern to see how we can best fit research into the needs of operations."

Using Data at Hand

Dr. W. C. Lowdermilk, associate chief of the Service, who presided at the research session, stated that usable information has been accruing through the years in other bureaus, in the Office of Experiment Stations, and in the State experiment stations. He directed attention to the plan of cooperation with State institutions, originating at a meeting in Chicago in May with 22 directors of State experiment stations present. As a result of this conference, an amended memorandum of understanding was drawn up and submitted as a basis of agreement with State agricultural experiment stations. Forty-five such memoranda have already been submitted, signed, and approved by experiment station directors and the Secretary of Agriculture.

In discussing the functions of research, Dr. Lowdermilk stated that it should, first of all, serve operations. The results of our studies should constitute the basis for our work, he said. He noted that a principal reason for rapid progress made thus far is to be found in the research experience of many operations men, which enables them to interpret and adapt the findings of experimentation. He favored the development of annual meetings at erosion experiment stations, and saw an opportunity for research to be a mentor to the Service as a whole. Finally, he pointed to research as a means of foreseeing agricultural needs and preparing the way for a permanent agriculture.

In such research, State coordinators and project managers are expected to have an important share. An exploratory survey of research already accomplished is under way, which is expected to yield (1) recommendations for discarding control methods regarded as ineffectual, (2) recommendations for continuing measures which have proved their worth, and (3) questions on which information is badly needed and on which may be developed research programs for the States.

The Work Spreads

C. B. Manifold, Chief of the Division of Conservation Operations, reported that a recent survey made to determine the voluntary acceptance of our program on lands not under agreement indicates that soil-conserving practices have been adopted on as much land outside the demonstration and camp areas as that on which agreements have been signed within project and camp areas. He pointed out that this wide spread of practices was due to the care in the selection of project areas, the development of working plans, the sound application of approved soil and water conservation practices and the cooperation of the extension service and other agencies in bringing these practices to the attention of the public.

He advocated a policy of rigidity in field administration, allowing for such modification as may be dictated by special conditions.

Mr. Manifold directed attention to the systematized plan of field inspections by the Washington technical staff. He indicated that from time to time members of the field staff will be brought into the Washington office to review operation procedure and assist in field inspections.

He discussed the need for maintaining cost and production records of nursery stock as well as accurately maintaining the general cost records.

Throughout the conference, the disposition was to look around and to look ahead: to orient, coordinate and cooperate in current activities, and to plan and prepare a permanent program.

FLOOD MENACE AND EROSION PROBLEM CHALLENGE SCIENTISTS OF MANY FIELDS

Information Consolidated at Noteworthy Upstream Engineering Conference

Following closely upon the adjournment of the Third World Power Conference and terminating in the epochal Young Men's Conference On Behalf of a Continent, the Upstream Engineering Conference held in Washington, D. C., September 22–23, brought to common focus the viewpoints of the sciences directly concerned with soil- and water-conservation.

For the first time in the history of the United States, outstanding specialists in soils, erosion, geology, agronomy, forestry, horticulture, wildlife, hydraulics and other branches of engineering, came together to compare notes on how to prevent floods and to save wasting farm lands.

Tuesday Morning

Dr. Robert A. Millikan, chairman of the executive council of the California Institute of Technology, sounded the gavel for the opening session on Tuesday

UPSTREAM ENGINEERING CONFERENCE

SEPTEMBER 22 AND 23, 1936

ORGANIZING COMMITTEE

HUGH H. BENNETT, Chief of Soil Conservation Service
MORRIS L. COOKE, Administrator of Rural Electrification Administration
F. A. SILCOX, Chief of the Forest Service

AUTHORIZATION

Hon. HENRY A. WALLACE, *Secretary of Agriculture, Washington, D. C.*

JUNE 16, 1936.

MY DEAR SECRETARY WALLACE:

Upstream engineering will have a major part in efforts to save the land and control floods, and for that reason it offers a broad field of opportunity for the engineering profession. I am therefore in hearty accord with your suggestion that there be held an open conference on the subject in early fall. The date might well be in proximity to that of the Third World Power Conference in September, in the hope that some of the distinguished foreign engineers attending the latter may be interested also in contributing to the proposed conference.

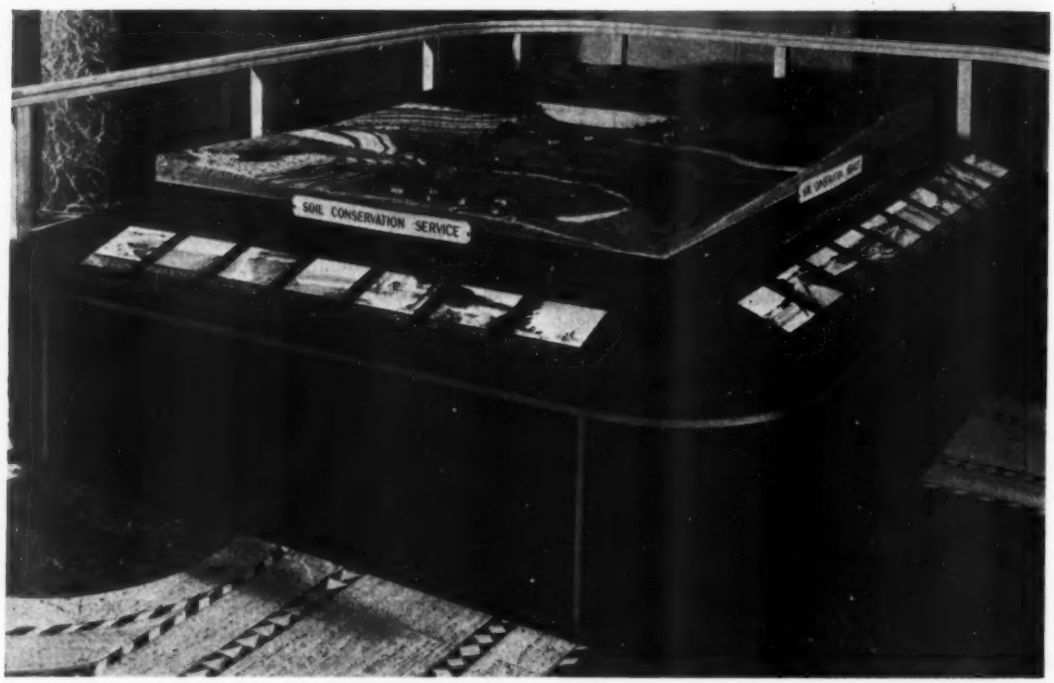
There are indications that a substantial body of technical information on the control of little waters is now available in the scattered records of American experience—Federal, State, and professional. The urgent problem is to bring these data together in a coordinate body of engineering knowledge so that public officials and engineers may have a more definite picture of the upstream engineering as an important field of public and professional activity.

There is a wealth of experience and data as to downstream engineering and works required for navigation, power development, and flood control—levees, large dams, great reservoirs, and channel improvements on major streams. But necessary as these are for the safeguarding of those who live in areas subject to destructive floods and of property located therein, it must be remembered that downstream waters originate largely in upstream areas. The objects of upstream engineering are, through forestry and land management, to keep water out of our streams, to control its action once in the stream and generally to retard the journey of the raindrop to the sea. Thus the crests of downstream floods are lowered.

In accordance with your further suggestion I am appointing as a committee to organize and promote such a conference or institute: Hugh H. Bennett, Chief of the Soil Conservation Service, Department of Agriculture; Morris L. Cooke, Administrator of Rural Electrification Administration; and F. A. Silcox, Chief of the Forest Service, Department of Agriculture.

Very sincerely yours,

FRANKLIN D. ROOSEVELT.



General exhibit of the Soil Conservation Service, which attracted widespread interest and comment from members of the Upstream Engineering Conference.

morning, September 22, and also filled the role of toastmaster at the dinner session that evening.

The first meeting featured papers by Dean Thorndike Saville, of the College of Engineering, New York University, and President Isaiah Bowman, of Johns Hopkins University.

Dean Saville, leading a discussion of Basic Principles of Water Behavior, termed the common view that rainfall is a result of evaporation from the ocean a misconception. He urged a scientific program of coordinated research in headwater control and land- and water-conservation. He declared that less than 30 percent of the rainfall of the United States comes from oceans, as compared with 70 percent by evaporation from the land.

Hydrologic Cycle Cited

Proof of this, his paper pointed out, is found in the study of the hydrologic cycle. Careful measurements, he said, show that the water level of the ocean is practically constant; therefore, that part of the rainfall which results from ocean evaporation cannot exceed the amount of water which flows back into the ocean. While run-off studies are woefully incomplete and rainfall estimates suffer from the same handicap, nevertheless they indicate clearly that much more water falls on the land than runs off. The remainder comes from land evaporation and from transpiration of plants.

Dean Saville suggested the setting up of thousands of transpiration and infiltration measurement stations. He warned, however, that data alone will not solve the problems of up-stream engineering and recommended a carefully conceived program covering all aspects of the problem and commanding the efforts of various governmental and nongovernmental agencies.

Cumulative Drainage

In a companion paper on The Influence of Vegetation on Land-Water Relationships, Dr. Bowman asserted that waste of water and its attendant evils have done more damage to the United States than war.

"We have been too long in the wild Indian stage, willing to scalp the land and leave it a red horror", he told his hearers.

Conservation of land and control of water must be carried out in three stages, Bowman said. First,

science must determine the nature and extent of the problem; second, management plans must be evolved from scientific plans; and finally, there must be cooperation between government and individuals in applying standardized practices.

"When the drought and dust storms come, we hear of prayers for rain by families or whole communities", Bowman said. "It would be far more sensible to pray for intelligence enough to take proper care of the soil and its cover when there is no drought. But steady, long-range work is apt to be neglected as soon as we think that the evil genii are on holiday. This is a bad business, for the conservation of land and water means also the conservation of people."

More Study Needed

Pleading for more extensive studies of long-range weather conditions, Bowman said: "We have hundreds of observers at rainfall stations gathering data for short-range weather predictions. But we have few sifters of the readings and recorded facts to get at the long-range meanings.

"The rain that affects a holiday or a shipment of perishables may seem important at the moment, but it is the effect upon vegetation and soils that in the long run determines whether people can live in an area or have perishables to ship or can afford a holiday."

Bowman declared that the long-range headwater problems of water and land cannot be solved without an understanding of the values and uses of watersheds as a whole. Upstream engineering, he concluded, is "fundamentally a social question with aesthetic, economic, political, and educational aspects."

Dr. Lowdermilk Speaks

Five-minute floor discussions at this session of the conference were by William Peterson, director of Extension Service, Utah State Agricultural College; LeRoy K. Sherman, consulting engineer, chairman of the Section of Hydrology, American Geophysical Union; Forrest Shreve, desert laboratories, Carnegie Institution, Tuscon, Ariz.; Carl O. Sauer, head of the department of geography, University of California, and W. C. Lowdermilk, associate chief of the Soil Conservation Service.

Dr. Lowdermilk spoke, in part, as follows:

"Dr. Bowman's paper is an important contribution to the literature on upstream engineering, involving the conservation of soil and water resources. The essential harmony of the complex of factors which make up land resources, including soil, vegetation, and water, has been appropriately emphasized. Moreover, the necessity of treating the resources of a drainage area as a whole—that is, as a unit—in the problems of upstream engineering, has been properly brought into clear relief.

"Dr. Bowman has laid his principal emphasis upon the influence of natural vegetation, such as forests and grass, on the regimen of streamflow and the conservation of soil. This leaves us the opportunity to call special attention in this discussion to the dramatic changes wrought in natural harmonies by clearing land of its native cover and the cultivation of such bared soils to necessary agricultural crops * * * .

"Surficial run-off from rains approximating an intensity of 2 inches in 1 hour was found to occur in the following order: From native forest, 2 percent; from grass land, 5 percent; from fields in close-growing grains, 25 percent, and from row crops such as corn and cotton, 50 percent. Run-off from fields in corn or cotton may be 25 fold that from forests under intense rains. Thus, these several conditions rank in reverse order as to rate of intake, namely, for forests 98 percent, for grain fields 75 percent, and for fields in row crops 50 percent. The most acute phase of the problem of land-water relationships in flood control and upstream engineering resides in the sloping lands cleared for cultivation.

Run-Off Differences

"The full import of these dramatic differences is arresting. It seems at first thought improbable in view of the absence of similar effects in the channels of major streams. The apparent lack of continuance of the dramatic differences in run-off in small areas to large streams has created confusion in the conclusions of many students of the problems of floods and streamflow. This point has been discussed more fully by me in other papers. In a general way, the expected run-off per square mile diminishes as the size of a drainage area increases. For example, run-off per square mile for certain areas in the Mississippi Valley will exceed 2,000 second-feet for a single square mile, whereas the run-off for the entire Mississippi drainage is approximately 1 second-foot per square mile. This wide difference in run-off from small and large areas is due principally to the relative size of areas contributing run-off; in small drainages the entire area may contribute to flood run-off, in large drainages only a fraction of the entire area will contribute to flood run-off.

The larger the drainage, the smaller will be the proportion of the area contributing to flood run-off. Thus measurements of run-off in major streams obscure the progressive trends in run-off characteristics of small areas. The behavior of major streams can be used neither as a measure nor as a criterion of the conditions of infiltration or absorption on small areas. The nature of processes at work within a drainage may be known chiefly by the responses on small areas, i. e., at the beginnings. Similarly, an estimate of the future condition of a landscape under agricultural uses must be inferred primarily from upstream phenomena. The downstream effects are resultants of a maze of interrelated factors which defy evaluation. For downstream flood control works must be designed on the basis of probabilities or combinations of factors."

As the discussion proceeded to the application of fundamental concepts in land management and engineering, the acting chief of the Forest Service, Earl H. Clapp, brought out the fact that floods on the Mississippi have increased greatly since the first white man saw the river in a major overflow in 1541.

"Natural factors favorable to absorption have been greatly reduced in many drainage basins of the United States as a result of exploitation of our natural resources", the speaker pointed out. "We have an accumulation of evidence showing the intimate relation between increases in floods and erosion and the increased depletion of forests and range cover."

He set forth a three-point program for watershed control:

1. Reestablish and maintain a balance between vegetation, soil, and water.

2. Devise a method of land-planning that will release for the common good the other resources and services of watersheds insofar as they will not interfere with soil and water conservation.

3. Fullest economic use of engineering devices, both temporary ones to make possible the restoration of vegetation and permanent ones to supply controls which vegetation alone cannot give.

Mr. Clapp's paper was augmented by brief remarks from Clarence F. Korstian, director of Duke Forest, Duke University; Clarence L. Forsling, director of the Appalachian Forest Experiment Station, and Leigh J. Young of the School of Forestry and Conservation, University of Michigan.

Highlighting consideration of the management and use of agricultural lands was a paper by Dr. H. H. Bennett, Chief of the Soil Conservation Service. Dr. Bennett told the Conference that in his opinion the era of land exploitation and extravagant waste of water resources in this country is nearing its end.

Paper by Dr. Bennett

"We are beginning soberly to realize", Dr. Bennett declared, "that our traditional American indifference or unsympathetic attitude toward the conservation of natural resources is leading us into a complexity of economic difficulties—good soil and needed water wasted, dust storms, stream channels and reservoirs glutted with silt, record floods. We are learning that we have been a prodigal nation and that the magnificent natural heritage with which we began our career as a nation is not inexhaustible. In a new sense we are becoming land and water conscious.

"That new conservation machines are being manufactured in increasing quantity and variety—machines for conserving soil and water, such as terracers, subsoilers, and basin listers—is but a sign of the times, as I see it. I am convinced the movement cannot be arrested.

"In the Soil Conservation Act of 1935 Congress for the first time recognized accelerated erosion as a national menace and declared it to be the policy of Congress 'to provide permanently for the control and prevention of soil erosion and thereby to preserve natural resources.' Out of this forthright declaration evolved the Federal-State program of soil and water conservation now in progress through the coordinated land-protection program of the Soil Conservation Service over far-flung parts of the country.

"And the Flood Control Act of 1936 is of historic significance, also; for it is the first time, to my knowledge, that the part of the agriculturist in flood control has been officially and specifically recognized by Congress.

Silt deposit on original flood plain soil.

"In what I have said to this Conference—to you who have joined in this effort to bring together the best ideas and plans of our several specialized fields in friendly cooperation for developing a far-reaching, comprehensive program to the upper limits of watersheds—it will be thoroughly understood, I believe, that agriculture is not proposing a substitute for flood-water fortification downstream. I am convinced you appreciate that what the agricultural specialists are offering is what, in all good faith, they consider upstream reinforcements to downstream operations by conservation work on the land where floods begin and where silt loads are picked up. The immediate task ahead is to agree upon a simple procedure of cooperation and coordination, whereby the engineer and the agriculturist will be working and thinking and planning along the same line, and for a common purpose. When such a procedure is mutually understood and cooperatively put into effect, I am confident that we shall then be definitely on the way to success.

"Furthermore, I believe that the way has been marked, the pattern cut. Those who have the vision and the will to move forward in unison—downstream along our major waterways, upstream along the little waters, and out into the fields and pastures and woodlots, on the ranges and far into the mountains—will find a supporting hand in the farthermost corners of this progressive Nation.

"We must ally our forces to defend ourselves against floods and soil erosion, for these are also allies, but allies in destruction.

"My thesis is that the proper treatment and management of land—soil husbandry, if you please—is more instrumental than any other individual factor in determining the rate and volume of rainfall run-off and the consequent loss of soil from given agricultural areas. I believe sufficient information is now available to say with confidence that the frequency of moderate floods can be reduced and the crests of abnormal floods definitely lowered in many trunk streams by proper land treatment, which means efficient land protection, over the contributory watersheds. Downstream engineering work must continue to carry a very large share of this responsibility; but it may reasonably expect assistance upstream where efficient adaptable measures of soil and water control are applied to the ultimate limits of our little waters. Already 1,397,000 check dams and 178,000 permanent dams in gullies and small drainages have been constructed; and, to date, a vast amount of protective work has been carried out on the lands of some 35,000 cooperating farmers, as well as on many millions of acres of public lands."

Conceding that there have always been floods, Dr. Bennett declared that a study of alluvial deposits reveals that the sediment laid down in the past 50 to 75 years was brought down by more violently flowing waters than those of former times. The recent deposits are coarser and less uniform than the earlier layers, showing that widespread stripping of natural cover followed by cultivation resulted in more violently flowing water which means high floods.

Dr. Bennett said he envisages upstream control as a reinforcement to downstream operations and not as a substitute. With approximately 100,000,000 acres of crop land already destroyed or seriously damaged and another 100,000,000 acres still in cultivation but stripped of most of its top soil, erosion looms as a danger to the well-being of the Nation, Dr. Bennett pointed out.

Dr. Bennett cited the South Palouse watershed in the State of Washington as an example of successful soil- and water-conservation practices. Previously the stream alternated from a raging torrent to a dry bed. During the past 2 years it has flowed steadily in spite of the lowest rainfall on record. Trout have returned to the stream for the first time in more than two decades and general stream conditions are approaching those of 35 years ago before the advance of agriculture.

Referring to research, he said: "Much * * * remains to be done in this field; we do not, by any means, know all that we should know about fundamental principles involved with either water or wind erosion, nor have we acquired all the information needed in the way of practical measures for control and prevention. Our investigations thus far have shown, for example, that sheets of water flowing across certain peculiar soils involve loading and unloading behaviors with respect to silt, as well as peculiarities of abrasive planation and incision, that are almost entirely outside present understanding. For example, we know little about the hydraulic principles under which as much soil material is removed from an area of narrow width, on certain types of land, as from one of much greater width. As a matter of fact, very little attention has been devoted to this abstruse phase of hydraulics, as well as numerous other processes in this field, which involves, perhaps, as many variables and complexities as any branch of dynamics. We have not even initiated investigations in relation to

differential erosion, and we have scarcely touched the field of subsoil tillage, especially in its adaptation to particular subsurface structures and consistencies as a practical means of stimulating water conservation by infiltration.

"* * * we have acquired far too little information with respect to the amount of water that falls on the land. The astounding peak of the disastrous 1935 flood in the Republican River is an illustration in point. That peak climbed far above any curves likely to have been projected on the basis of rain gage records within the watershed of that stream or of neighboring streams. Even the precipitation readings for the rain that brought on the disaster do not account for the prodigious volume of water that charged down the valley; somewhere between the established gages the rainfall must have attained intensities wholly out of line with any actual measurement."

Dr. Thornthwaite Participates

Casting further light on Dr. Bennett's reference to rainfall, Dr. C. W. Thornthwaite, head of climatic and physiographic investigations for the Soil Conservation Service, spoke informally as follows:

"In illustrating the deficiencies of essential data for the development of proper methods of upstream soil and water conservation, Dr. Bennett referred to a climatic project being operated by the Soil Conservation Service in western Oklahoma. In this survey precipitation records are obtained from 200 rain gages concentrated in 3 counties and spaced at an average distance of 3½ miles. From these records maps showing the fall in each 15-minute period and others showing the accumulated depth of precipitation are made. Over 800 such maps were required to chart the rainfall distribution for the month of May 1936. The maps of a rain which occurred in the late afternoon of May 1 are presented for the Conference on the chart in the Soil Conservation Service exhibit.

"The 10 maps on the left side of the chart show the amount of rain which fell in each 15-minute period between 4:45 p. m. and 7:15 p. m. In this series it is possible to trace the migration of the storm and the development and change of the centers of greatest intensity. The 10 maps at the right show the accumulation of precipitation from 7 a. m. until 7:15 p. m. During this period of time more than 3 billion 500 million cubic feet of water fell on the portion of the Cimarron watershed included in our project.

In a subsequent issue the magazine will carry excerpts from some of the other papers presented before the Conference. Complete proceedings of the Conference are being prepared or publication.

"The studies carried out on this project suggest an entirely new approach to the flood problem. We propose to study the characteristics of complete storms; determine their areal extent, their usual migration pattern, their intensity distribution, their total water contribution, and the pattern of the rate of fall. Statistical studies will determine the frequency distribution of rates of fall for storms having various size, shape, and migration characteristics. These facts can be applied directly to watersheds of known area, configuration, and cover to determine the probability of fall of rainfall of certain amounts and rates. From this the extent of flood hazard can readily be determined."

Other commentators from the floor included Noble Clark, assistant director Agricultural Experiment Station, University of Wisconsin; Samuel H. McCrory, chief, Bureau of Agricultural Engineering, United States Department of Agriculture; George E. Condra, dean of the conservation and survey division, University of Nebraska, and Robert P. Holdsworth, forestry department, Massachusetts State College.

Dinner Program

Addresses at the dinner included Big Waters and Little Waters, by Maj. Gen. Edward M. Markham, Chief of Engineers, War Department; The Human Value in Upstream Engineering, by Charles Harris Whitaker; Building Toward a Permanent Agriculture, by Jacob G. Lipman; and Control and Use of Little Waters in France by Inspector General Magnein, Administration of Waters and Forests, Paris, France.

Wednesday Morning

Immediate completion of the topographic map of the United States and drastic revision and early completion of the soil maps of the country were urged before the Wednesday morning session of the conference by Robert E. Horton, consulting hydraulic engineer of Voorheesville, N. Y.

In calling for a coordinated program of upstream control, Mr. Horton also urged the installation of more rainfall and run-off recording gages and the immediate publication of all available ground-water level records.

The speaker took up the scientific aspects of run-off in minute detail. Even the humble earthworm came in for scientific evaluation when Mr. Horton showed that the amount of water filtering into the soil is greatly influenced by earthworm holes and other perforations near the surface of the soil. Plowing up the land destroys the natural pores, he explained.

Mr. Horton's paper was briefly commented upon by Walter N. White, senior hydraulic engineer, Water Resources Branch, United States Geological Survey, and George Knapp, engineer for the water-conservation and flood-control committee of the Kansas State Board of Agriculture.

Dean Clyde Appears

George D. Clyde, dean of the School of Engineering, Utah State Agricultural College, in discussing Control and Use of Small Streams, said that no water escapes from the Bear River Valley into Great Salt Lake without first having generated power, supplied irrigation demands, and filled artificial basins for wild-fowl development. Bear River was described as "the most completely controlled and utilized stream in the United States." It irrigates 420,000 acres of land supporting 63,000 people, and generates 73,000 horsepower of electric energy.

Dean Clyde termed control of small streams to permit more efficient use of water and to prevent erosion and flood damages an urgent need throughout the United States. He favored control structures based on sound designs and rigid specifications with careful inspection upon completion of the work.

Dividing the country at the 100th meridian into two distinct problems he said the problem in the eastern half is disposal of water, while in the semiarid regions of the West conservation of water is the primary concern. Both demand control of flow, if maximum usefulness and protection is to be obtained. Control structures in the East serve to reduce flood crests; in the West they seek to retain the water for irrigation purposes.

Dean Clyde's paper was amplified from the floor by Edward R. Jones, chairman of the department of agricultural engineering, University of Wisconsin; and Abel Wolman, chairman of the Water Resources Committee, National Resources Committee.

Wednesday Afternoon

The final session of the Conference listened to The Comprehensive Engineering Point of View as set forth in papers by Sherman M. Woodward, chief water control planning engineer, Tennessee Valley Authority, and Ralph U. Blasingame, head of the agricultural engineering department, Pennsylvania State College.

Mr. Woodward cited records taken in Imperial Valley, Calif., where between 1 and 2 million acre-feet of water a year is passing into the air. Before the coming of irrigation some 30 years ago no such evaporation existed, he said. Yet there is no evidence that the climate has changed in the least. He declared that,

"Although Weather Bureau records show great variations in the amount of precipitation from year to year in all parts of the United States, authorities generally agree that there are in different regions cycles of wet years and cycles of dry years extending over varying periods of time, and that our records of precipitation are too brief to show any definite change in climate or that man's activities have had any effect on the amount and distribution of precipitation."

Many Fields Involved

Mr. Woodward spoke of the necessity of scrutinizing a wide range of scientific information before planning measures of control:

"The science of soil management occupies a borderline field touching, on one side, the physical sciences of hydrology, climatology, physiography, hydraulics, and agricultural engineering; on another side, the biological sciences relating to ecology and plant growth and production; on a third side, the sciences dealing with the economic and cultural factors involved in human occupation and use of the land. The program of the conference up to this point has been a sufficient demonstration of the complicated and involved nature of the many interrelations between these various sciences."

Final Word From Morris L. Cooke

A democratically chosen "moderator" for every major and minor watershed who would be without legal authority, yet represent the interests of the citizenry in the conservation of soil and water was suggested by Morris L. Cooke at the closing session.

"If we are to save our lands and make better use of our waters", Mr. Cooke said, "we must work out a national procedure which utilizes local autonomy as part of a coordinated national body politic." State compacts, State and regional planning boards, and authorities such as T. V. A. were cited as possible answers to the problem of coordination.

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"Our battle against dust storms, droughts, floods, and especially soil erosion is being retarded by 'the disease of distance'", Mr. Cooke said. "What we need is that all citizens—north, south, east, and west—face the fact that soil erosion is going on over a large part of the cultivated area of our country, and that the variations are chiefly those of the tempo at which the destruction is being effected.

"No section of the country can be allowed to be ravished beyond a certain point without the rest of the country suffering", he warned. "The irrefutable fact is that within a relatively limited time, as the history of Nations goes, practically all the plowable lands will be ruined unless in the meantime we learn the technique of defense and apply it."

Mr. Cooke's message elicited discussion from the floor by Lt. Col. Glen E. Edgerton, Office of Chief of Engineers, War Department; Charles E. Holzer, president, Ohio Valley Conservation and Flood Control Congress, and Harlan H. Barrows, head of the department of geography, University of Chicago.

Much of the success of the Upstream Engineering Conference is attributed to the skill with which its sessions were directed from the rostrum. In addition to Dr. Millikan, presiding officers at the several sessions included Dr. Hugh P. Baker, president, Massachusetts State College; Frederick N. Feiker, executive secretary, American Engineering Council, and Frederic A. Delano, vice chairman, National Resources Committee.

THERE WAS NO CONFERENCE THEN

"If western land spoilers knew how eastern land skinners had skinned their land to death, they would not go on doing just the same thing. But they won't know, and, of course, won't do." . . . Solon Robinson wrote this warning on December 10, 1845.

See the book review, on page 108 of this issue

SERVICE SUFFERS LOSS THROUGH DEATH OF HENRY M. EAKIN

Henry M. Eakin, head of the Section of Sedimentation and Hydraulic Studies, Division of Research, died in Washington, D. C., October 20.

Mr. Eakin was born June 12, 1883. His undergraduate studies were pursued at Nebraska Wesleyan University and the University of Nebraska and followed by postgraduate work in geology and physiography at the University of Chicago.

From 1906 to 1918 he was with the Alaskan branch of the United States Geological Survey, after which he was engaged in the private practice of engineering in Seattle, Wash. In 1929 he was with the Dominion Explorers of Canada making geological investigations in the Canadian Northwest. From 1930 to 1933 he served as senior scientist for special investigations on sedimentation and river hydraulics under the Mississippi River Commission.

Since 1934 Mr Eakin had been with the Soil Conservation Service, first as specialist in sedimentation studies to organize a program of reservoir silting surveys, later as head of the section which embraces the field of downstream influences and effects of accelerated erosion and methods of control.

Mr. Eakin was an outstanding authority in his field and a writer much in demand. Intensely devoted to the cause of soil conservation, he was given to thinking far ahead of his generation. Shortly before his death he had the satisfaction of seeing fresh from the press his contribution, Silting of Reservoirs, issued by the Department of Agriculture as Technical Bulletin No. 524, which promises to stand as one of the most important publications of the Soil Conservation Service for many years. This bulletin is briefly reviewed on page 108 of this issue. Mr. Eakin was also a valued contributor to SOIL CONSERVATION.

A few of the many papers by Mr. Eakin follow:

The Influence of the Earth's Rotation upon the Lateral Erosion of Streams. Journal of Geology, Vol. 18, pp. 435–447, 1910.

Mineral Resources of the Yukon-Koyukuk Region, Alaska. U. S. G. S. Bull. 592, pp. 371–384, map, 1914.

River Engineering. (Encyclopedia Americana, 1920 and later Editions.)

Reservoir Silting Results from Preventable Erosion, Survey Shows. Soil Conservation Service, Soil Conservation, Vol. 1, No. 3, pp. 6–7, 1935.

The Twin Problem of Erosion and Flood-Control. Trans. Amer. Geophysical Union 17th Annual Meeting. pp. 436–439, 1936.

(With Glenn L. Fuller.) The Arrest and Prevention of Devastation by Floods. U. S. D. A. Soil Conservation Service, MP–12, 11 pp., 1936.

Meeting the Menace of Overflow Waters. Soil Conservation Service, Soil Conservation, Vol. 1, No. 6, pp. 5–6, 1936.

RESERVOIR SILTING IN THE NEW RIVER WATERSHED

By

Carl B. Brown

and

Farrell F. Barnes[1]

View upstream across Washington Mills Dam, Fries, Va., showing silt deposits within a few feet of crest level. Picture taken while reservoir being drained for double purpose of replacing flashboards and flushing sediment from 80-percent silted reservoir.

Investigations of erosion conditions on the New River watershed by measurements of silting in reservoirs have just been completed by a field party of the Section of Hydrodynamic Studies, Division of Research. A series of four reservoirs, 3, 6, 15, and 58 miles respectively, above Ivanhoe, Va., were surveyed to determine the amount and rate of storage depletion by silting. The results of the surveys also indicate, quantitatively, a minimum rate of soil removal to be expected from watersheds similar to that of the New River. A special feature of these investigations was a study of the effect of one or more reservoirs on the silting rate of other reservoirs downstream.

Watershed Conditions

An erosion survey by the Section of Conservation Surveys, Division of Operations, shows that approximately 78 percent of the New River watershed is either cut-over, pasture, or cultivated land, and that sheet erosion has been moderate to severe on all land which has not been protected by a woodland cover. The most severe sheet and gully erosion has occurred in the southern headwater part of the area, tributary to these reservoirs, where the soils were derived from schist and granite. The limestone soils in northerly areas, below the reservoirs, are not subject to severe gullying under present farming practices.

Location and Description

The Fields Dam—to begin at the upstream end of the series—is 4 miles northeast of Mouth of Wilson, Va. The original reservoir had a maximum depth of 8 feet, a length of 1.3 miles, and a storage capacity of 184 acre-feet. Washington Mills Reservoir, at Fries, Va., about 43 miles below Fields Reservoir, was originally 40 feet deep at the dam, with a length of 1.6 miles and a storage capacity of 2,954 acre-feet. Byllesby Reservoir, 9 miles downstream from Fries, had an original maximum depth of 52 feet, a length of 3.4 miles, and a storage capacity of 8,892 acre-feet. Buck Reservoir, 3 miles below Byllesby, was originally 20 feet deep at the dam, with a length of 1.1 miles and a storage capacity of 1,225 acre-feet. Washington Mills Dam was built in 1902, Byllesby and Buck in 1912, and Fields in 1930, so that their ages are approximately 33, 24, and 6 years, respectively. (See table.)

Character of Sediment

The sediment in these reservoirs consists of dark gray, very fine silt, mixed and interstratified with varying proportions of fine to coarse sand, and minor amounts of organic material. There is very little change in character from one reservoir to another, except in the relative proportions of silt and sand. In general, the deeper reservoirs contain a larger proportion of silt, but even in these the relatively strong currents, characteristic of narrow channel lakes, have swept large quantities of medium to fine sand virtually to the dam.

Results of Investigation

Original and present capacities and silt volumes were determined for each reservoir by special field methods, involving the preparation and comparison of contour maps of the original and present basins of Washington Mills and Byllesby Reservoirs, and direct measurements of silt thickness by silt-sampling spud and auger at Buck and Fields Reservoirs. The

[1] Mr. Brown is associate geologist and Mr. Barnes is junior engineer, Section of Hydrodynamic Studies, Division of Research, Soil Conservation Service.

(*Continued on p. 106*)

AGRONOMY HEAD TOURS PROJECTS AND REPORTS TO CHIEF

WELL, DR. BENNETT, I found that a good many of those New Jersey farmers are mulching their orchards. They're cutting broomsedge, hauling it, and spreading it on the ground so that it serves much the same purpose as a cover crop. They like the idea of Reed canary grass for seeding on wet lands, the crop to be cut and used between their peach and apple trees. They are planting their new trees on the contour, too; although some of them object to this in square fields because they can't get in as many trees as they want. Other farmers appreciate the value of protected soil at the cost of a few trees. The main point is, though, that they like to keep their orchards in sod or sod strips whenever possible. It was encouraging to me to find orchard grass, a shade-loving plant, growing under the trees, even though there is some trouble with curculio which lives over in such vegetation.

Mixed Plantings

I know you will be gratified, as I was, to learn that all throughout the Northeast there is much interest in mixed plantings of alfalfa and grasses such as timothy, brome, orchard, or tall oat grass. At several of the experiment stations I was told that their experiments indicate some excellent points in favor of mixtures. The mixtures avoid heaving in the alfalfa; they keep out weeds, and avoid bloat in grazing; and the crops make fine hay. And, what is more important, a mixture is most efficacious in the control of erosion. In the Northeast they favor brome and timothy over orchard, tall oat, or meadow fescue, as the former are more palatable to livestock.

Those Northeast farmers are interested, likewise, in winter cover crops seeded at the last cultivation of corn and other row crops. They're using rye, winter barley, and wheat.

Tobacco and Legumes

In the tobacco fields of Maryland I found the same tough problem in erosion control that is so prevalent in Virginia and the Carolinas—that of a poor quality of tobacco from soils treated with legumes. It is my opinion that redtop and domestic rye grass as winter cover crops offer the best solution at the present time.

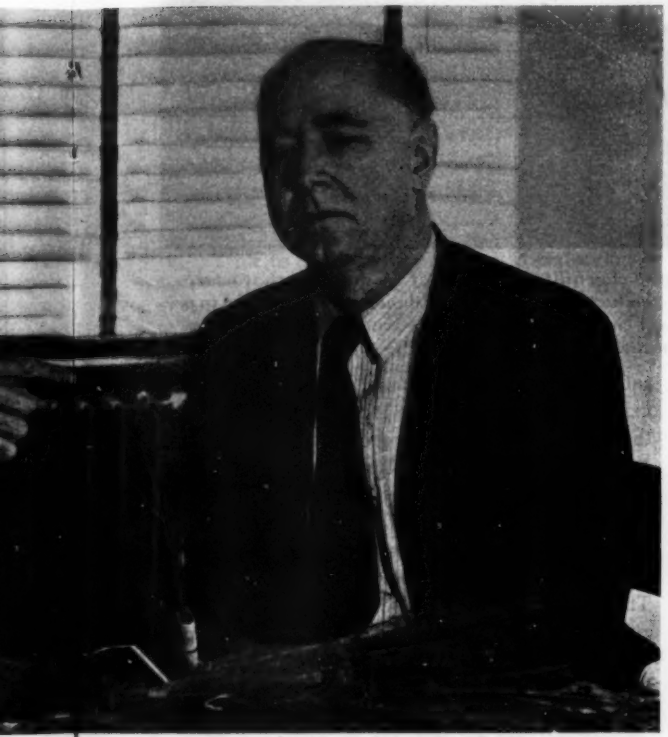
"Switch grass is a valuable perennial pasture plant, not particularly with the Chief of the Soil Conser

As to the reseeding of gullies, there is a general tendency to use too many species of plants and too much seed. Experimental results indicate that rather light grass seedings, on poor land, with considerable fertilizer, show to the best advantage. The difficulty about a thick stand of grass on a poor soil is that it develops slowly and soon thins out. The use of two or three species that grow well under such conditions is more economical, and therefore more satisfactory, than to use several species in the hope that some of them will grow.

Narrower Strips

I was interested to know that Maryland farmers who are strip cropping—using corn in strips—have voluntarily reduced the width of the strips. This is true, also, in the Northeast, where corn is cut and

Charles R. Enlow, fresh from a field inspection, sits down with Dr. Bennett for a chat about how farmers are using vegetation to control erosion. His notes yield many interesting suggestions and reflect the progress of one important phase of the Soil Conservation Service program. Mr. Enlow directs the work of the Agronomy Section.



, not particularly liked by grasshoppers." Mr. Enlow talks things over of the Soil Conservation Service.

shocked for feed. Reduction of the strip widths allows the farmer to place his shocks on the adjoining meadow strips and, at the same time, clears the corn land. Such a procedure is most convenient when the farmer starts cultivation for seeding of subsequent crops.

There is one thing that should be mentioned in connection with strip cropping—our need for machinery that will work on a contour slope. The bean pullers work well on level land or up and down hill, but on the contour they are not at all satisfactory. This, as you know, is true of other machinery.

Out in Ohio I found an exceptionally fine demonstration of strip cropping on the project at Zanesville. Farmers are pleased with the plan to reduce strip widths for more convenient handling of the corn and of land after the corn is removed. On the Zanesville project it is quite apparent that a good method of stabilizing gullied land is to fence it in and allow grass and weeds to take hold. Such a procedure is more economical than the more elaborate method of building structures and setting trees, and certainly it justifies the purchase of fencing materials.

At Zanesville there is need for additional pasture work. Much could be done in the rotation of permanent pastures, in the planting of supplementary pasture crops, the use of fertilizers, more extensive use of contour furrows, and perhaps some reseeding.

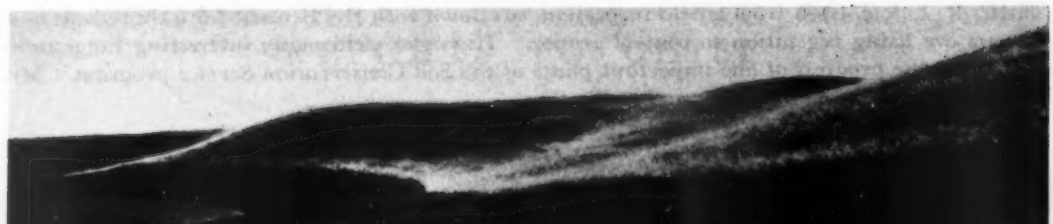
Illinois Meeting

I know you are anxious to hear how the agronomy meeting at Urbana, Ill., turned out. It really was well worth while, although the program was much too ambitious for the one day. Detailed discussion was necessarily limited. It seemed apparent from the meeting, however, that the agronomic program for Region 5 is in general a sound one. It includes the proper use of rotations, strip cropping, contour tillage, the establishment of meadows and pastures, improvement of pastures, and, in some cases, the combination of terracing and strip cropping. I need not tell you that there is always difficulty in deciding the problem of land-use. Given a rapidly eroding area what should be done with it? Should it be retired to trees and pasture? Or, is the land in such condition that cultivation may be continued while best known erosion-control methods are introduced and practiced? It is a question which requires a great deal of thought.

Pasture Disking

In Region 5, I found that pasture disking, with the application of phosphate fertilizers and the seeding of legumes, is a more or less general practice. At the regional meeting I heard considerable argument over the use of small amounts of fine lime in establishing legumes, and I am convinced that this phase of the work needs further investigation.

If you want to see some first-class strip cropping, you'll find it at the project at Winona, Minn. Prac-



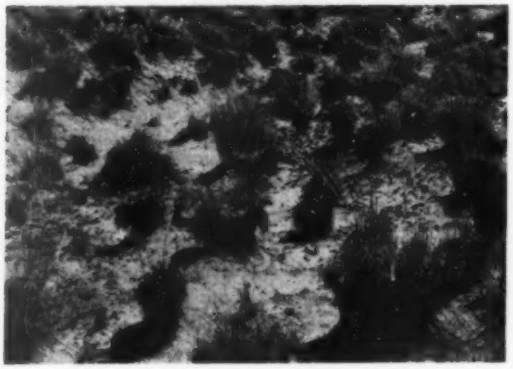
As result of snow and wind action, typical North slopes and clay hilltops in State of Washington characterized by bad erosion which makes them submarginal for wheat production. Steep lands shown here dedicated to permanent seeding of alfalfa and grasses; erosion and run-off checked and yields approximating 2 tons of hay to the acre obtained.

tically the entire project is stripped and fences have been moved to the contour. The pasture improvement work is outstanding and the entire project shows a very well-balanced program. All but six farmers in this project are under contract. The type of work in Minnesota can best be judged by the fact that a check-up on land adjacent to one project and two camps showed that 52 farmers outside the project areas have put into effect, of their own volition, part or all of the practices used by the erosion-control program.

Native Grasses Look Good

I am sorry to say that at Mandan, N. Dak., the terrible drought is having its effect on the nursery. The irrigation water available is decidedly limited, and grasshoppers are so numerous that it is almost impossible to increase seed of the plant introductions and native collections. Several of the native grasses, including switchgrass, big and little bluestem, and the wheat grasses, look very good in spite of the severe conditions. On the range land, blue grama did not start growth all summer.

Little bluestem, fighting to retain its hold on life and soil.



The project at Lander, Wyo., presents some interesting problems. One of them is wind erosion which, under irrigation, is very severe on a part of this area. The problem is being handled in excellent shape, however, by forage-crop acreage increase, and by stripping where beans or other crops to be removed are grown. In one instance a farm which was bought for $400 a few months ago is now valued at more than $4,000—the increase due largely to the work of our Service.

Light Rainfall

In this project the rainfall is too light to justify the use of contour furrows. The better method for erosion control on the range land is the provision of water holes for livestock and shorter grazing seasons, both fall and spring. It is well to reduce fall grazing 1 month, so that the grass may mature to seed; while a 15-day reduction in spring grazing allows opportunity for spring growth. Overflow water from the water holes is spread on low level land by the use of a level irrigation ditch. This method is very economical and practical, and it should be tried extensively in other regions.

Out at Pullman, Wash., I found the grass nursery in splendid condition. More than 2,000 strains and species of introduced and native grasses and legumes are under observation, and many look very promising.

New plots have been seeded and it looks as though this nursery is to become outstanding in the future development of grasses.

Effect of Program

You are always interested, Dr. Bennett, in knowing how our demonstration work is spreading beyond the borders of the project areas. I think I am none too extravagant when I say that the Pullman erosion-control project has transformed the surrounding country. With 10 percent of the land on hilltops and steep slopes in permanent hay, the landscape presents a beautiful appearance. An excellent rotation program is being used and at the same time an attempt is being made to encourage the farmers to seed spring wheat. Little erodible fallowed land is visible from the hilltops, and at the present time the area, as viewed from above, appears to be largely covered with vegetation. The present fallow recommended includes rough tillage with crop residues kept at or near the surface.

Reseeding Activities

The project at Emmett, Idaho, shows some excellent results from the reseeding of range or abandoned cultivated land with native and cultivated grasses and legumes. The drilling of grasses on cheat land without soil preparation seems to have real possibilities. Land about Emmett that has been protected from grazing shows quite a stand of native perennial bunch grasses, and it is expected that this will improve greatly as time passes, providing the land is protected from grazing for such a time as is required for the grasses to spread and take foothold. This is even more true on the flood-control project at Pocatello,

Green manure cover crop of rye offers protection to land and aids fertility.

Reed canary grass, of which Mr. Enlow speaks, is adapted to both wet and dry lands, is an excellent erosion-control crop, and produces a fair quality of hay. (Photographs by courtesy of the Wisconsin College of Agriculture.)

Contour furrows in Texas prove their worth in water- and soil-conservation.

Idaho. There very fine stands of native wheat grass, bluegrasses and fescues, are noticeable with 1 year's protection, whereas in the beginning nothing could be seen but cheat and Russian thistle.

Furrows—Large or Small?

At Pocatello the entire project is being contour furrowed; but here again it is felt that the furrows are too large and too far apart. This practice, if it is to be adopted by the farmers, must be put on a basis whereby the average farmer can carry out the operations with an ordinary plow or similar farm implement. Shallow contour furrows, close together, keep the land passable, mowable, and farmable, and give proper utilization of moisture. Where the problem is largely flood control, however, such as at Pocatello, it may be advisable to include some large furrows.

Damming Lister Used

At Colorado Springs I saw excellent results from the contour furrows established last year, and considerable success has been achieved in reseeding these furrows with several of the native grasses. Sweet clover seedlings in the furrows, and old plants of western wheatgrass, growing up through the ridges, are most promising. Two hundred acres have been seeded to pure stands of different grasses for seed increase. A damming lister has been used very successfully in preparing the land for grass seedings on the contour between contour furrows. This applies particularly to land taken out of cultivation and abandoned land.

The strip cropping at Colorado Springs is an excellent illustration of the use of practical common sense. The farmers' needs are paramount and are given first consideration. In spite of the fact that it has been very dry at Colorado Springs, some good results have been obtained in range seedings with sweet clover, *Elymus canadensis*, *Agropyron smithii*, *Agropyron cristatum*, and smooth brome. Due to the excessive drought, blue grama is not so much in evidence at the present.

Kansas Grass Work

The grass nursery work at Manhattan, Kans., is in excellent shape. Very interesting, and outstanding, is the selection and breeding work conducted by the Kansas Experiment Station and the Bureau of Plant Industry, on bluestems, blue grama, buffalo grass, and other grasses. Seeding methods for various native grasses are being studied. Row seedings, with a firm seed bed, appear to give best results. Con-

siderable progress has been made in Colorado, Kansas, and Oklahoma, in the development of machinery for seeding of native grasses.

All in all, I think I am safe in saying that strip cropping is becoming the outstanding method for control of erosion throughout the country. The main argument against it is that heard in livestock countries—inability to graze the aftermath of hay strips because of their proximity to corn and other growing crops that need to be protected. As for this drawback, it can be overcome by the segregation of crops within fields. For example, all corn can be grown in one field stripped with hay crops; wheat in another, etc. Such an arrangement allows the meadow strips to be grazed, if desirable, after the wheat is cut; and by rotating the corn, wheat, and other nongrazing crops between fields, rotation grazing of the aftermath is possible.

Run-off water used for flood irrigation produced this hay.

ONE FARMER'S PROFITS FROM BLACK LOCUST

By Morris Fonda [1]

Black locust posts valued at $250 to $300 an acre are being harvested from a 20-year growth by Ivy Joyner, Shawneetown, Gallatin County, Ill.

In 1915 Mr. Joyner decided to put some of his rough, hilly ground into tobacco and plowed the area without attention to the seriousness of the erosion problem which might result.

Sprouts Take Field

A few large black locust trees were scattered over the field, however, and in plowing, the roots were disturbed so that a dense growth of locust sprouts resulted. During the next 2 years the locust sprouts became so numerous that all hope to continue cultivation of the field was abandoned. Today the 20-acre plot is producing some of the finest locust trees in Illinois.

By selling regular posts at 20 cents each and corner posts at 50 cents each, Joyner has an income estimated at more than that from the rest of his farm. He is contemplating fencing off the entire area for tree production, even though it is fairly good farming land.

Browsing Permitted

No especial care has been given the stand of locusts, and for the first 3 years about 60 head of sheep and a half dozen head of cattle were allowed to browse at will.

Here's the statistical summary for one cut-over acre the last three seasons:

	Winter 1933-34	Winter 1934-35	Winter 1935-36
Labor-man days	17	17	20
Number of posts	835	835	1,000
Cash received	$250	$250	$300

[1] Forester, Edwardsville, Ill., project, Soil Conservation Service.

WOODLAND ARTICLE IN DECEMBER

Owing to the pressure of upstream engineering material in this issue, it has been found necessary to hold over until December the concluding article in the woodland series: Woodland, a Part of the Farm Plan, by John F. Preston.

HOW MAIN STREET BECAME THE BIG DITCH[1]

By Ross Calvin

The famous old-time floods of Silver City, N. M., made history—but they also made the Big Ditch. And they made it from a standing start in the 10 years from 1895 to 1905.

The first history-making flood occurred July 21, 1895. The rainfall in that month was unusually heavy—six inches, in fact—yet it was less than that of July 1875, about equal to that of September 1875, much less than that of July 1881 and of August 1881. One wonders why the large-scale excavation of the Big Ditch was deferred until 1895. Perhaps the answer will not be difficult to find.

A photograph dated 1891 shows that the level of San Vicente arroyo—known then as Main Street—was practically the same as that of the bordering ground. Across Main Street, near where the opposite end of the bridge now rests, was the famous three-story Timmer house, whose heavy foundations still are traceable. On the opposite corner stood the cabin where Billy the Kid spent his boyhood. Flanking the latter, was the two-story building of *The Silver City Enterprise*. Farther downstream, as we speak of it today, rose the general store of Crawford and Porter, boasting a half million dollar stock, and the mercantile establishment of John Morril. This was the setting of Silver City's Main Street—the San Vicente arroyo of today—during the early nineties. Then on Sunday night, July 29, 1895, came a mighty flood.

Newspaper Description

Says THE SILVER CITY ENTERPRISE in its issue last week:

At 8:45 last Sunday evening the long prayed-for rain came, and came in torrents. The somber clouds which for hours had hung threateningly over the Pinos Altos range, precipitated their pent-up flood upon the steep hillsides adjacent to Chloride Flat, which gathered the waters into a compact volume, from which place it swept down the narrow gorge with terrific force upon the town of Silver City.

[1] This sketch is based upon a longer article by Dr. Calvin which was published in the *New Mexico Magazine*.

Oxen hauling wood on Main Street, Silver City, N. M., in 1886.

Looking north up Main Street from Yankee Street crossing during 1900 flood.

This flood, which attained its maximum in force and volume at 10:30, was the largest ever seen at Silver City up to that hour carried away the walls of the Broadway corral, the rear walls of the Broadway hotel, and worked general destruction.

The waters of the first flood had receded below the danger limit at 11:30 when the great bank of clouds which darkened the sky to the northwest came in contact with the towering peak of Bear mountain, the highest in all the Pinos Altos range. As if the bottom of a sea were punctured by the peak, a vast volume of water descended, accumulating in force as it converged in streams from the mountain sides, making a river in the canyon which leads through the town.

At 11:45 this flood struck the town in an immense wave, twelve feet in height and three hundred feet in width, carrying with it everything movable in its path. Down through the heart of town, through the principal business streets, it swept, entering the houses through every crack and crevice, filling cellars full and overflowing, bursting open doors and smashing large windows, running through the first floor of nearly all the houses a depth of two to four feet . . . the velocity must have been fifteen miles per hour . . . The tumult of the waters charged with debris of every kind, carrying boulders weighing tons, trees and fallen timbers from the mountains, which acted as battering rams, struck the buildings with a force and noise which carried consternation and fear to the hearts of those within hearing distance. . . .

The big iron safe which was washed out of the post office was found below the dam, high and dry on one of the banks of the creek. . . .

Doctor Williams, J. R. Johnson, and Sheriff Shannon formed a rescue party which went to the relief of A. J. Loomis and family. Doctor Williams, while carrying the little boy, was thrown down by force of the waters and went under twice, the boy clinging to his neck. Messrs. Johnson and Shannon, holding each other's hands, waded in and caught hold of the doctor, pulling him out with the child, all thoroughly drenched.

Dell Potter and family were asleep at their home in the little cottage next door to the Tremont house, when the flood came on every side of the house, cutting off all possible means of exit and escape. The furniture was all afloat and the family drenched in three feet of water. Mr. Potter took an axe and cut a hole through the roof and placed his family on top of the house and then climbed up himself, and all waited in painful suspense for the waters to recede.

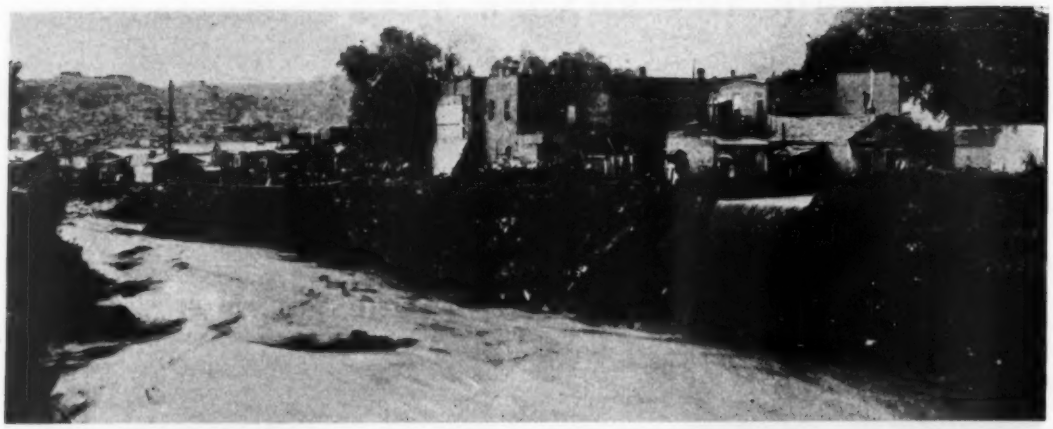
As the years went on and the denudation of the watershed proceeded with no one doing anything to retard or prevent it, the town began to go in for disastrous floods in a really large way. Two occurred on successive afternoons in August, 1903. And it is a conspicuous fact that it no longer required a monthly rainfall of six inches to cause the deluges. That year the rather common August precipitation of 3.8 inches sufficed. Each year as over-grazing and wood-cutting continued, the watershed became more completely denuded.

The editor of the Silver City Independent writes on August 18, 1903:

. . . It was thought that the erection of a dam at the foot of Main Street would put an end to further trouble, but its failure to withstand last week's flood demonstrates that the force of mountain freshets in this country cannot intelligently be calculated upon. . . There is but one absolutely safe remedy, and that is the removal of the business portion of town to a higher ground.

. . . The breakwater or dam mentioned above had been erected at a cost of $15,000 to the village, and represented an expression of both hope and despair. It failed in the first test.

Besides the habit of carrying down buildings, saddlehorses, and other livestock, the baleful leaping torrent indulged occasionally in



Looking south down Main Street from Market Street crossing during flood in 1902.

a *tour de force*. Such was the abduction of Judge Newcomb's piano from the second story of a substantial brick building. Eyewitnesses tell what happened. Though a heavy rain had fallen over the mountains, the sun was shining on Silver City. With a sinister roar, the red flood came racing down, battering its banks with floating trees. The front wall of the building, badly undermined, at length fell with a crash. The floor partly robbed of support sagged quietly. The thousand-dollar grand piano rolled forward a bit. As the floor sagged again, the great instrument broke with a ponderous lurch from its moorings, rolled forward—and plunged. The spectators gasped as the massive ebony case went bogging and rolling downstream as though it had been a cigar box.

Afterwards Mr. Carter went to look for the piano. Seven miles downstream he found it.

A combination of causes, of which overgrazing was the chief—overgrazing not alone by range cattle, but

This is the way the street-gully looked in 1906 from Market Street crossing.

"Main Street" in 1936, showing Soil Conservation Service revetment work.

by woodcutter's burros, by pack animals freighting machinery to the mines, by saddle horses, and the like—was carrying denudation to a dangerous extreme in the years before 1895, though the culmination was not reached until July of that year.

Matters continued to grow worse instead of better for several years thereafter, with the result that floods increased in frequency. Meanwhile the formidable Big Ditch which had been Main Street took on the aspect of a canyon. Below town it cut an irregular trough some 15 miles long, which for long stretches is today 50 feet wide and walled in by perpendicular banks 15 feet high. Thus, millions of tons of fertile soil area were carried away, and from lack of water for trees, lawns and flower beds, Silver City took on a look of barrenness.

Then in 1908 The Gila Forest reserve was set aside and placed under Federal control. Very, very slowly nature began to regain its balance, 10 years elapsing before the process of revegetation made much headway. However, vegetative cover gradually increased and floods gradually diminished in number and violence. Now there is far more ground cover, with many young trees over the north end of the watershed, where there is an almost complete absence of old trees. Floods are fewer and smaller because there is less run-off.

For a full generation the Forest Service has been restricting the number of grazing permits in order to prevent damage to the land. It has also vigorously been attempting to prevent forest fire depredations, and nowadays timber-cutting is permitted only on a basis of perpetually-sustained yield. The ruinous drought of 1934 brings out the result of the control with striking effectiveness—for the wells which in former drought years used to be in a chronic state of shortage this year supplied all needs of the town. At a recent meeting the city council attributed a large amount of credit for the increased water supply to the labors of the Civilian Conservation Corps during the preceding year.

So the history of denudation and erosion here has been a typical, though a sad and stupid one. Possibly nowhere in the wide Southwest is there a more striking exhibit of man's interference with nature than Silver City's Big Ditch.

View downstream across Washington Mills Dam, showing silt deposits in foreground. Crest of dam originally 40 feet above stream bed.

SILTING IN NEW RIVER WATERSHED

(*Continued from p. 95*)

results of these surveys are summarized in the following table.

Reservoir	Fields	Washington Mills		Byllesby	Buck
Age (years)	5.67	33.5		23.66	23.66
Original capacity (acre-feet)	183.81	2,954.24		8,892.16	1,225.33
Present capacity (acre-feet)	109.22	511.47		3,338.35	941.51
Sediment:		1922	1936		
Acre-feet	74.59	2,363.96	2,442.77	5,353.81	283.82
Percent original capacity	40.58	80.02	82.69	60.21	23.16
Storage loss per year:		1902–22	1922–36		
Acre-feet	13.16	118.20	5.84	226.28	12.00
Percent original capacity	7.16	4.00	.20	2.54	.98

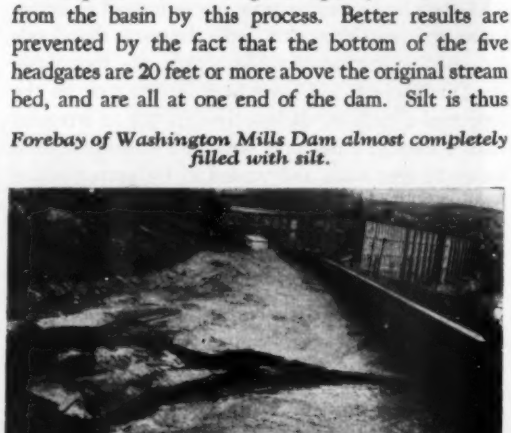
The foregoing table gives the average rates of storage loss for the entire period of each reservoir except Washington Mills. A survey of Washington Mills Reservoir made in 1922 yielded sufficient data so that the storage capacity at that time could be determined. From this information it was possible to compute the amount and rate of storage depletion in the two periods 1902–22 and 1922–36. It was found that in 1922 Washington Mills Reservoir had lost 80.02 percent of its original capacity, at the rate of 118.20 acre-feet per year, and at present is 82.69 percent filled with sediment. These figures indicate that the reservoir was as full as possible in 1922, after a period of 20 years. Since that time practically all sediment entering the reservoir has gone on past the dam because the available storage had decreased beyond the point where additional silt could permanently settle. This would mean that the present capacity of 511.47 acre-feet, which closely represents the capacity during the past 14 years as well, is little more than the volume of a normal section of channel of the same length as the reservoir, maintained by the flow of the New River. As a check on the above conclusion, the approximate velocities which should exist within the range of stage of the New River, in a channel with the given average cross section, were computed. The results show that the high velocities would probably scour material accumulated during periods of low river stage but that lower velocities would allow deposition. In other words, the channel cross section is in a condition of equilibrium, but varies between rather definite limits, determined by maximum and minimum river stages.

Greatly Reduced Capacity

Excessive silting presents a serious problem at Washington Mills. The storage capacity of this reservoir has been so greatly reduced that the operators find it necessary to supplement their own generators at intervals by purchased power. Frequent shut-downs are required in order to sluice out the intake to the generators. Silt accumulates so rapidly in the forebay that a mud valve at the lower end, opened in November 1935, was covered with 6 feet of mud when the valve was again opened 5 months later. A fire hose is used to open up a channel in the silt above the generators by hydraulic methods. This process is necessitated three or four times a year.

Another practice followed at Washington Mills is to open the headgates from the forebay to the river below the dam, allowing stored water and normal discharge to drain out rapidly, washing silt with it. On April 18, 1936, 6.76 acre-feet of silt—equal to 1.32 percent of the storage capacity before draw-down, or 0.23 percent of the original capacity—was flushed from the basin by this process. Better results are prevented by the fact that the bottom of the five headgates are 20 feet or more above the original stream bed, and are all at one end of the dam. Silt is thus

Forebay of Washington Mills Dam almost completely filled with silt.



Clearing silt from mud valve by hydraulic method. Six feet of sediment accumulated here between November 1935 and April 1936.

scoured from a single narrow channel extending about 2,000 feet above the dam, and to only about one-half the depth of the deposit, leaving the greater part untouched.

Buck and Byllesby Reservoirs, particularly the latter, have also lost a large part of their original storage capacity, with a corresponding impairment of full capacity operation at times, during critical low-water season.

The Fields Dam is so low that it has no appreciable storage, but serves for diversion only. Silting has, therefore, had no material effect on plant operation.

Silting Rates in Series

All four of the reservoirs are channel lakes, very little wider than the original river channel. The gradients of the original river channel within the reservoir basins, in feet per mile, were as follows: Washington Mills, 28; Byllesby, 15.6; Buck, 22; Fields, 6.

The results of the surveys indicate that the presence of such a channel-type reservoir even a short distance above a projected dam site is no insurance against storage loss by silting of the new reservoir. For example, although Byllesby Dam is only 9 miles below Washington Mills Dam, it has silted at the rate of 226 acre-feet per year, an annual rate of 2.54 percent of the original capacity. However, Washington Mills Reservoir is estimated to have lost at least 65 percent of its original capacity, and hence most of its effectiveness as a silt trap, by the time Byllesby Dam was constructed. A better example is Buck Reservoir, only 3 miles below Byllesby and constructed at the same time. This reservoir has lost 23 percent of its original storage in a period of 24 years, despite the presence of a much larger reservoir a short distance upstream. Since no tributaries enter the New River in the intervening 3 miles, practically all the sediment in Buck Reservoir must have passed over Byllesby Dam.

Rate of Erosion

In order to develop the significance of the rate of silt accumulation in relation to drainage area, the following data were computed:

Total sediment in all 4 reservoirs	acre-feet	8,154.99
Age of oldest reservoir	years	33.5
Average annual accumulation	acre-feet	243.43

Since the determined average rate of sedimentation in these reservoirs is a general index of minimum rates of net erosion of the watershed, the above figures may be expressed as follows:

Total area of watershed	square miles	1,320
Annual accumulation per 100 square miles of drainage area	acre-feet	18.44
Annual accumulation per acre of drainage area	cubic feet	[1] 12.55

It is certain, of course, that an unknown fraction of the erosional debris had passed Washington Mills Dam and on down the New River before the Byllesby and Buck Dams were completed. It is equally certain that another unknown volume has since passed over the latter two dams, the lowest in the series. Therefore, the above figures are less than actual net erosion on the New River watershed. However, they serve to indicate in a general way the probable rates at which further storage depletion of present or additional reservoirs in the New River series may be expected to take place.

Inasmuch as Washington Mills Reservoir is practically full of silt, Byllesby Reservoir is 60 percent full, and the smaller Fields and Buck Dams have but little remaining storage capacity, it is safe to say that, within a comparatively few years, the entire volume of erosional debris from the New River watershed will be passing unchecked downstream, at a rate exceeding 250 acre-feet per year.

This figure, of course, represents only an indeterminate fraction of the net erosion of the watershed, since it is evident that considerable stream-borne sediment passed the whole series of dams and other volumes of sediment are being deposited outside the reservoirs on channel bars and islands. Average losses of soil from the lands of the watershed are, therefore, much greater than 0.63 ton per acre and, as alluvial readjustments progress, a gradual increase in potential rate of silting of any additional reservoir constructed in the valley is to be expected.

[1] 0.63 ton (allowing 100 pounds per cubic foot).

BOOK REVIEWS AND ABSTRACTS

By Phoebe O'Neall Faris

SOLON ROBINSON Pioneer and Agriculturist, Volume I, 1825–45. Edited by Herbert Anthony Kellar. Indianapolis. 1936.

Here is a book that is bound to be hailed with enthusiasm by students of American agriculture, by prairie pioneer specialists in particular, and by the general reader whose interest in the development of the United States throughout the century that is past leads him to delve into the letters and published writings of men and women who traversed with ox teams the boundless rich land to found towns and to build farm homes.

A man of parts, Solon Robinson was first of all wholeheartedly an agriculturist. He wrote with pungency, on many farm subjects, for many papers. He traveled widely and observed keenly; he was a prairie settler—a squatter, in fact—and he was the founder of Crown Point, Indiana. The land in the vicinity of his first prairie cabin was known as Robinson's Prairie, and as such it appears on contemporary maps today. In 1838 he wrote one J. Buel, of the *Albany Cultivator:* "Dear Sir: What can, what must, what shall we do, to elevate the standing of the cultivators of the soil?" and thus began a famous crusade for a National Society of Agriculture which resulted 3 years later in the formation of such an organization. Although the society was short-lived, it set in motion forces which culminated in the establishment of the United States Department of Agriculture in the year 1862.

That Solon Robinson had vision and a progressive spirit is evidenced by his many writings advocating scientific practices which, although truisms in this day, were daring and novel to the farmers of his time. In 1845, while on a visit to the John T. Leigh plantation in Mississippi, Robinson wrote of the "great and indispensable improvement upon Mr. Leigh's farm" in the form of hill-side ditches. "Now, if anybody should ask 'what are hill-side ditches?' I have to say, that the whole of all the numerous hill-sides are ditched with one or more ditches, as may be necessary to take up and carry off all the falling water, almost on a level, and winding round till an outlet can be found to discharge it without injury to the land. These ditches are laid off by a level, and are intended to remain permanent fixtures; and all the plowing has to conform to their shape, and as a matter of course, utterly annihilating 'straight rows.'"

On the subject of grasses and terracing to prevent erosion of the soil, Robinson was enthusiastic, and at the same time disgusted with farmers who ignored his soil waste warnings. Of the Bermuda grasslands he wrote, "the tenacity of life in it (Bermuda grass) is so great that some people object to admit it upon their land for fear that they never could get rid of it. In fact it would seem that they would prefer to see their land taking its rapid course down the millions of gullies through which some of the finest soil in the world is sweeping its way rapidly toward the Gulf of Mexico, rather than risk the trouble of getting this grass into their cultivated fields * * *. For, be it known, this is the land of gullies * * *. Now the very worst of these waste gullies can be reclaimed into the best of pasture, and the further waste prevented by Bermuda grass alone, and that in 1 or, at furthest, 2 years. It will even adhere to the perpendicular sides of banks, and in the bottom of ditches it will grow and collect the wash, and again grow up through the accumulating dirt, and again collect another coat of wash so that it not only prevents the further waste, but in a measure will fill up many of the smaller gullies already formed."

Throughout his career Solon Robinson was persistent in his strong advocacy of many and varied farm home and soil improvements. The use of fertilizers—lime, guano, marl, animal manure, swamp muck; deep plowing; better rural architecture and more adequate ventilation in farm dwellings; protection of animals from the weather; keeping of weather records; cultivation of trees, shrubs, and flowers; diversification of crops; better pumpkin pies.

Many of his articles and addresses aroused heated argument among his readers and hearers, and brought forth hundreds of communications supporting his ideas or denouncing them. Often he varied his farm writings by dwelling on other topics. He criticized the State penitentiary system of Tennessee, advocated a flat rate of postage, called attention to a new method of printing invented by Josiah Warren; discussed people and places and ideas encountered in his travels throughout practically every State then in the Union and portions of Canada. At times he resorted to fiction to tell the prairie story, and occasionally he produced some amusing but very bad poetry. In 1864 he produced a book of importance which was called Facts for Farmers.

A few titles from Robinson's writings which appeared in the New York Tribune will give some idea of the scope and variety of his agricultural interests: Perils of Prairie in Winter, Cotton Gin and Presses, Sugar Cane, Rice Culture, Orange Growing in Florida, Production of Turpentine, Home Grown Tea and Coffee, Oaks, Cypress, and Palmetto, Mountain Fruit Farm.

From the point of view of the soil conservationist the publication of the life and letters of Solon Robinson in two volumes during the 1936–37 period is an event both fortunate and timely. We want to know more and all there is to know about the man who, a century ago, wrote of the prairie after the second crop ". . . you have a deep, loose, rich black soil, which as you do unto it, so it will do unto you. The practice generally adopted is to take the skin and starve the body—burning straw and wasting manure—'running over' four times as much land as can be cultivated."

We await with interest the publication of volume 2 of the works of Solon Robinson.

SILTING OF RESERVOIRS. By Henry M. Eakin. Technical Bulletin No. 524, U. S. D. A. July 1936.

This bulletin presents data from silt observations and sediment measurements of significant reservoirs in the southeastern, southern Great Plains, and southwestern type areas of the United States, and shows conclusively that the silting of reservoirs is a practical problem of first order in all three regions, wherever accelerated erosion is in force. The report is designed to give a preliminary outline of the more important aspects of the problem, to summarize the results of studies made heretofore by other agencies, and to present the findings of the Soil Conservation Service during the fiscal year ended June 30, 1935.

Since data point to the fact that in the southeast reservoir silting results chiefly from erosion of deep residual soils as influenced by human occupation, it becomes increasingly apparent that much benefit can come from organized cooperation in the matter of improved terrace slopes. In the southern Great Plains silt detention above reservoir level is indicated, along with terrace and contour cultivation, cover and strip cropping, and control of incipient gullies. Higher rates of silting in the Southwest, due largely to overgrazing and resulting sheet and gully erosion point to the need for restricted grazing, mechanical structures in arroyo and gully, earth barriers above reservoir level in broad tributary outlays, and growth of vegetative screens in delta areas.

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